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PRELIMINARY REPORT ON SOIL-ROOTLET RELATIONSHIPS TO POLE BLIGHT OF WESTERN WHITE PINE [1]

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Results of a coordinated soil-rootlet mortality study in 1954 indicate that the severity of the pole blight disease of western white pine (Pinus monticola Dougl.) is significantly correlated with certain physical soil characteristics and rootlet mortality. The finding of this relationship does not necessarily imply that these factors are the cause of pole blight. Evidence reported herein was obtained from a detailed study of 6 healthy and 11 diseased 1-acre plots, well distributed throughout the white pine type of northern Idaho. This study is being continued.

SAMPLING PROCEDURES

Plots were established in selected white pine stands of the 60- to 80-year-age class. They represented 3 site quality classes in healthy and in light, moderate, and severe pole blight areas. Fifty soil samples, 6 inches in diameter and 12 inches deep, were collected from regularly spaced points about each plot to provide the root samples. Each of these samples was placed in a wire basket and the soil washed from about the roots. All white pine roots were separated and classified as either living or dead. Fine rootlets, less than 1.0 mm. in diameter and attached to major living roots (2.0 to 20.0 mm.), were tallied and recorded as either living or dead. In addition, a 1/4-acre plot was established in the center of each of the 1-acre plots, and root samples were taken at 2- and 3-foot depths at the 4 corners of each 1/4-acre plot. Total living root lengths were determined and recorded for the four 1-foot depth samples taken nearest the 4 corners of the center plot.

On the center 1/4-acre plot, a tally was made of all trees 0.6 inch in diameter or larger according to whether they were healthy or diseased. White pine trees unmistakably killed by pole blight were also tallied.

Two soil pits, located at diagonal corners of the center 1/4-acre plot within each 1-acre sample plot, were excavated either to rock or to a working depth of 48 to 60 inches. Soil profile descriptions at each pit were recorded, and such important features as horizon sequence, depth, color, texture, structure, consistence, mottling, cementation, and hardpan formation were noted. Slope, aspect, and topographic position were also recorded.

Field percolation rates were determined at 4 locations on each plot by measuring the recession of water at hourly intervals in water-filled ground wells of 1-, 2-, and 3-foot depths. Oxygen contents of the soil by successive 6-inch depths were measured with a portable Beckman oxygen analyzer.

Undisturbed core (volume) samples were collected by 2-inch depths from each soil pit to 36 inches wherever practicable. Loose samples, totaling 144 for 17 plots and representing distinct horizons, were collected for subsequent laboratory study.

LABORATORY TREATMENT OF SOILS

All core samples were brought to saturation in the laboratory. Moisture retention at 60 cm. of tension was determined according to standard procedures. Laboratory permeability rates, expressed as inches per hour, were determined under a free-water head of 1 cm. Bulk density values were subsequently determined on the same core samples. Moisture equivalent and xylene equivalent values were determined on the horizon samples according to standard centrifugal procedures. Wilting coefficients were measured on duplicate soil samples by using the pressure plate membrane apparatus under a pressure of 15 atmospheres.

Soil sampling depths were often limited by extreme rockiness on the Coeur d'Alene and Kaniksu National Forests. No difficulty was encountered in sampling on the Clearwater Forest.

The quantity of rock (particles greater than 2.0 mm. in diameter) present in each soil horizon was determined and expressed as a percentage of the total soil volume. These figures entered into subsequent computations.

RESULTS

On the plots examined in 1954, rootlet mortality ranged from 5.3 to 15.3, 6.2 to 10.3, and 1.8 to 4.0 percent in blighted stands, healthy stands in blighted areas, and healthy stands in disease-free areas, respectively. Since pole blight has not been found in the Clearwater Forest, this forest is considered a disease-free area.

Living rootlets of white pine in this disease-free area averaged from 1-3/4 to 13 times as numerous as those in both healthy and blighted stands within the known range of the disease. Qualitatively, rootlets in the Clearwater area appeared more vigorous, were longer, and possessed a greater number of attached fine rootlets than in the latter two types of stands.

A limited number of root samples taken from successive 1-, 2-, and 3-foot depths showed that slightly more than 50 percent of the rootlets and small roots, 1.0 to 6.0 mm. in diameter, occurred in the upper foot of soil throughout the white pine type. The remainder of the roots of this size class were rather evenly distributed in the 2- and 3-foot depths. On the other hand, approximately 80 percent of the roots 6.0 to 20.0 mm. in diameter and all lateral roots larger than 20.0 mm. in diameter were found in the surface foot of soil. Rootlet mortality was higher in the first and second foot of soil than in the third foot, and slightly higher in the first than in the second foot. A correlation analysis showed a highly significant relationship ($P = < .01$) between the increase in percent of rootlet mortality on the living trees and the increase in percent of white pine basal area affected (blighted and dead of pole blight).

As a routine laboratory operation, pH values of all horizon samples were determined. The minimum value measured was 4.76 and the highest value 6.80, giving a range from high to low of about 2 pH units. No significant correlation was found between pH and pole blight. Oxygen contents of the soils showed only slight variation between plots; less variation occurred in the surface soils than in the subsoils.

Bulk density values of the surface soils ranged from about 0.60 to 0.80, a few being higher, but at greater depths there was a concomitant increase in bulk density. Subsoils of 3 plots had bulk density values exceeding 1.60. Root penetration was restricted in these soils.

Because of the high rock content and high bulk density in some soils (factors likely to limit root development), an adjustment of actual soil depth to an effective soil depth was made to facilitate comparisons and more nearly measure actual soil depths available for tree root development. Available water-holding capacities of soils at each plot were obtained by subtracting the wilting coefficient from the moisture equivalent, and then converting these values to inches of available water.

In figure 1, available water-holding capacities in the top 32 inches of soil for the 17 plots are arranged in descending order. The severity of pole blight, expressed as a percentage of the total basal area affected by or dead of pole blight, is also shown. Although age of the individual stand infection may greatly influence

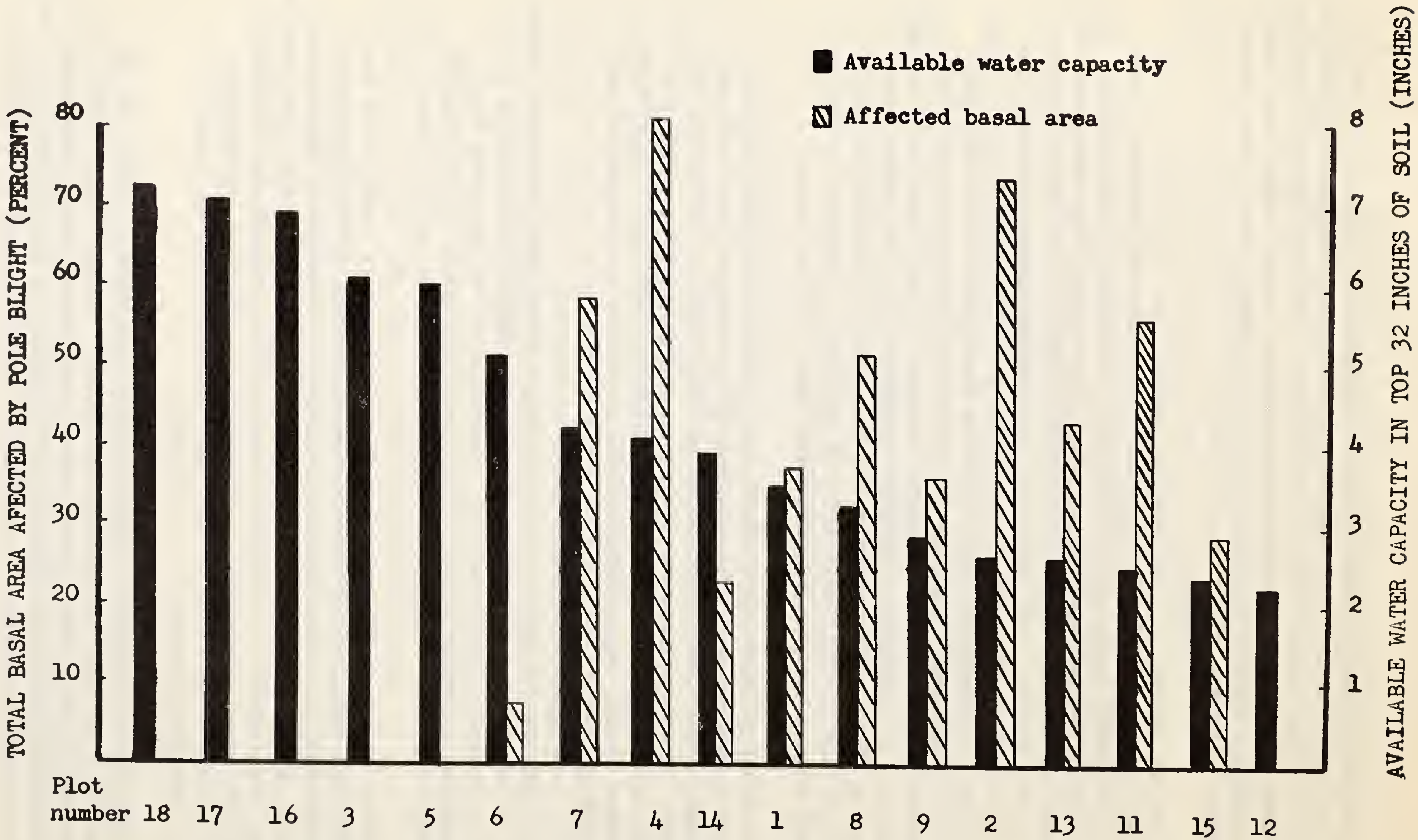

Figure 1. Comparison of available water storage capacity and the severity of pole blight.

the severity of pole blight as measured in this manner, the percentage of total basal area affected still appears to be the most feasible measure of pole blight now available. The tendency for pole blight to increase as the available water-holding capacity decreases is shown in this figure. The first 5 plots are healthy and have an average water-holding capacity of more than 6 inches in the top 32 inches of soil. Although plot number 12 has a low available water-holding capacity and is classified as healthy, nearby trees show some pole blight symptoms; it is suspected that this plot may be at the threshold of becoming blighted. For the 11 diseased plots, the average available water-holding capacity is approximately 3 inches in the top 32 inches of soil. These shallow, droughty soils appear to be associated with the incidence of pole blight.

DISCUSSION

Small numbers of rootlets and high rootlet mortality were both significantly correlated with pole blight at the 1-percent level. The data show that rootlet numbers increased significantly with an increase in total living length of the larger roots; this suggests that the health of a tree is conditioned by the size of its over-all root system.

No significant differences in various soil characteristics in the surface soil to a depth of 12 inches were noted when the plots were grouped according to pole blight condition. This fact is attributed to the occurrence of similar loessiallike soil material more or less uniformly covering the white pine forests to this depth. Major soil differences were noted in many of the subsoils. Of all the soil characteristics examined singly, those that influence soil moisture and its availability showed greatest significance. Individual correlation analyses revealed a significant relationship between the general condition of the root system and the moisture equivalent and effective soil depth. Using inches of available water-holding capacity in the top 32 inches of soil as the X variable and the percentage of basal area affected as the Y variable, the incidence of pole blight was found to diminish as the available water-holding capacity became greater ($P = .01$). The coefficient of determination for this correlation was .3974. When effective soil depth was combined with inches of available water-holding capacity, the coefficient of determination increased to .4880.

To test further the interrelationship of these factors, a multiple regression analysis was made between effective soil depth (X_1), inches of available water-holding capacity (X_2), total number of living rootlets (X_3), and the percentage of white pine basal area affected (Y). The equation derived was:

$$Y = 53.481 - 2.005X_1 - 17.924X_2 + 0.0024X_3$$

The coefficient of determination was .4908; this indicates that more than 49 percent of the variance in pole blight was accounted for by these 3 variables. When X_3 was excluded from the equation, the 2 soil variables still accounted for 48.8 percent of the variance in pole blight.

It appears, therefore, that under conditions of adequate soil depth and available moisture, the relative abundance or scarcity of rootlets has but little measurable effect on the incidence of pole blight. However, it is reasonable to assume that trees having a greater abundance of live roots are more likely to survive under repeated adverse environmental conditions than those having only a limited number of thrifty rootlets.